KAGRA+ Upgrade Plans

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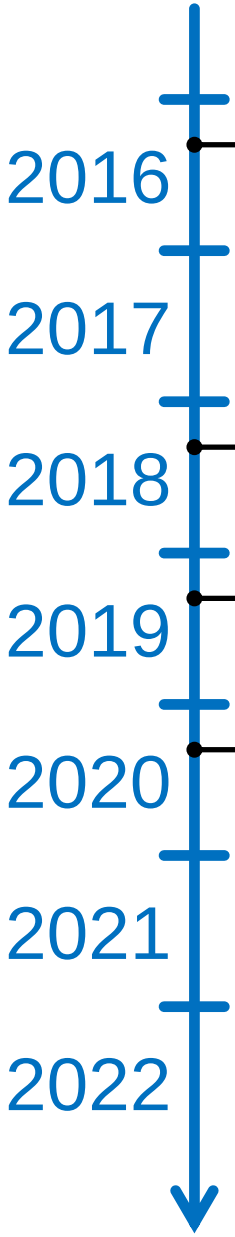
Overview

- No concrete plan yet
- Some R&D on-going
- Integrated study initiated recently
- Aiming at the first observation in 2022~2024, within current facility

時期的に
可能なのか？

KAGRA Timeline



Initial KAGRA (iKAGRA)
3-km Michelson
room temperature
simplified suspensions
First test operation

Phase 1
3-km Michelson
cryogenic temperature

Phase 2
3-km RSE
cryogenic temperature

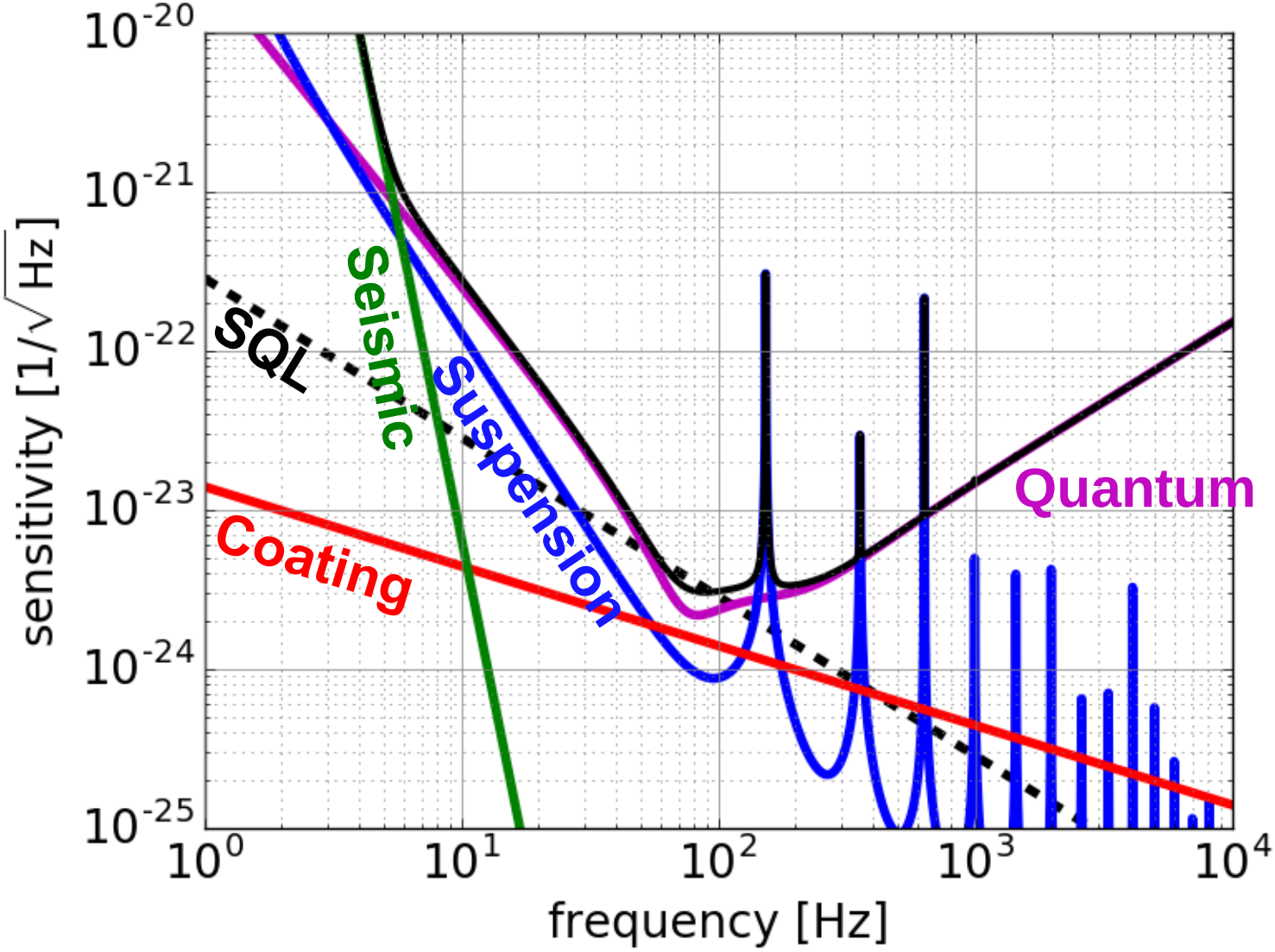
Phase 3
3-km RSE
cryogenic temperature
observation runs

Baseline KAGRA (bKAGRA)

KAGRA+ ?

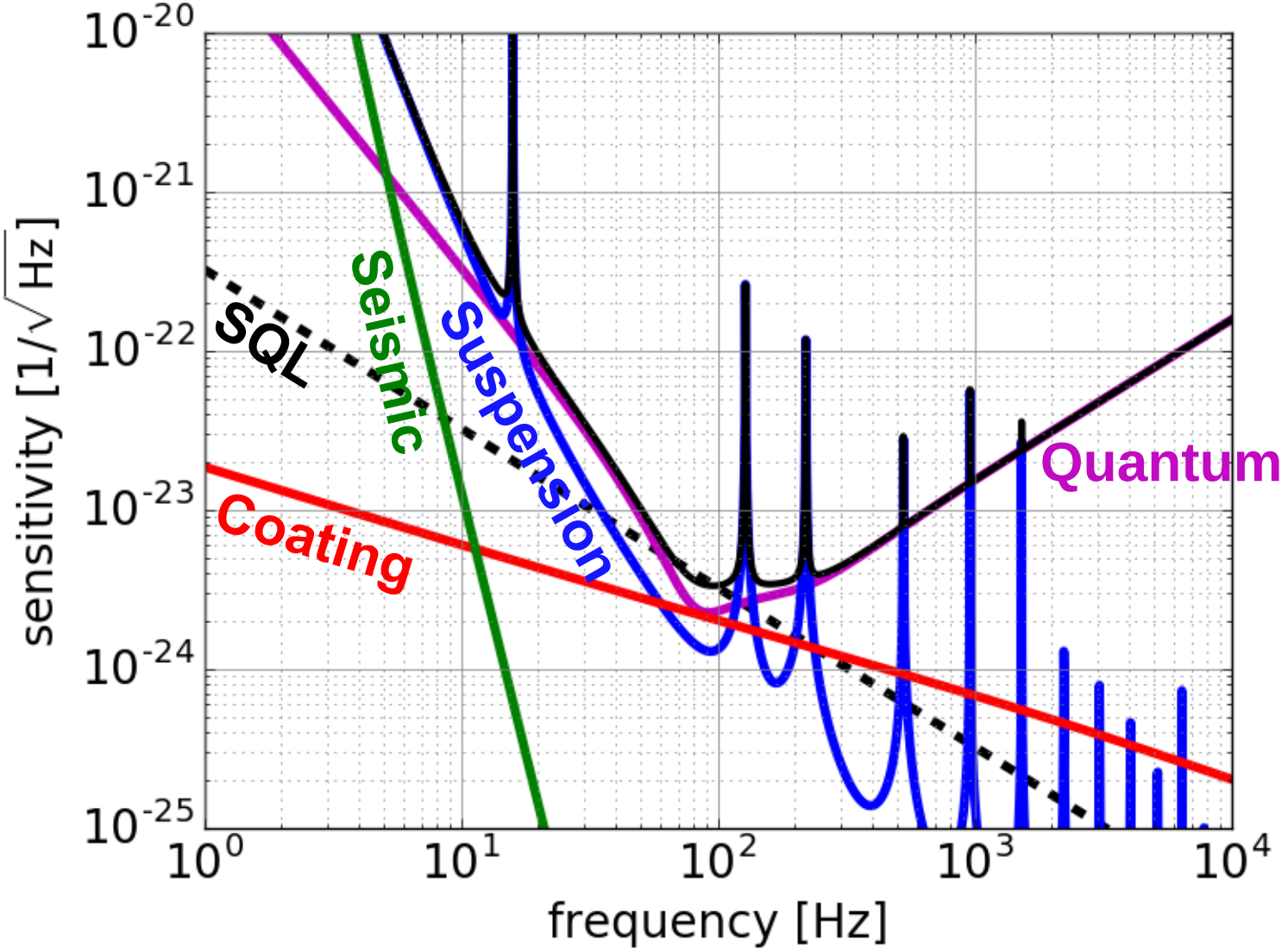
KAGRA Official Sensitivity (v2009)

- 30 kg, 20 K, 825 W at BS → BNS 171 Mpc



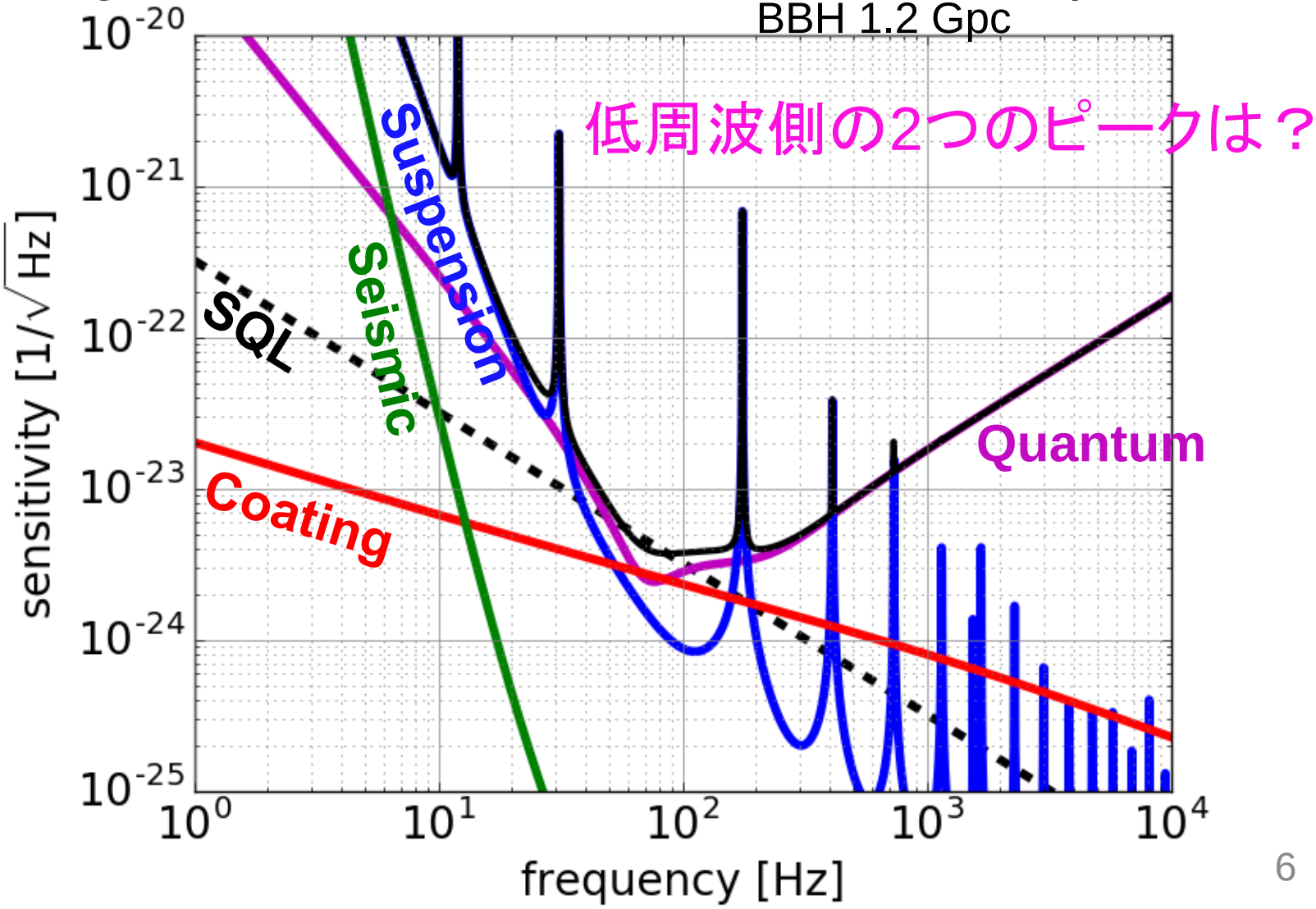
KAGRA PRD Sensitivity (v2013)

- 23 kg, 20 K, 780 W at BS → BNS 148 Mpc



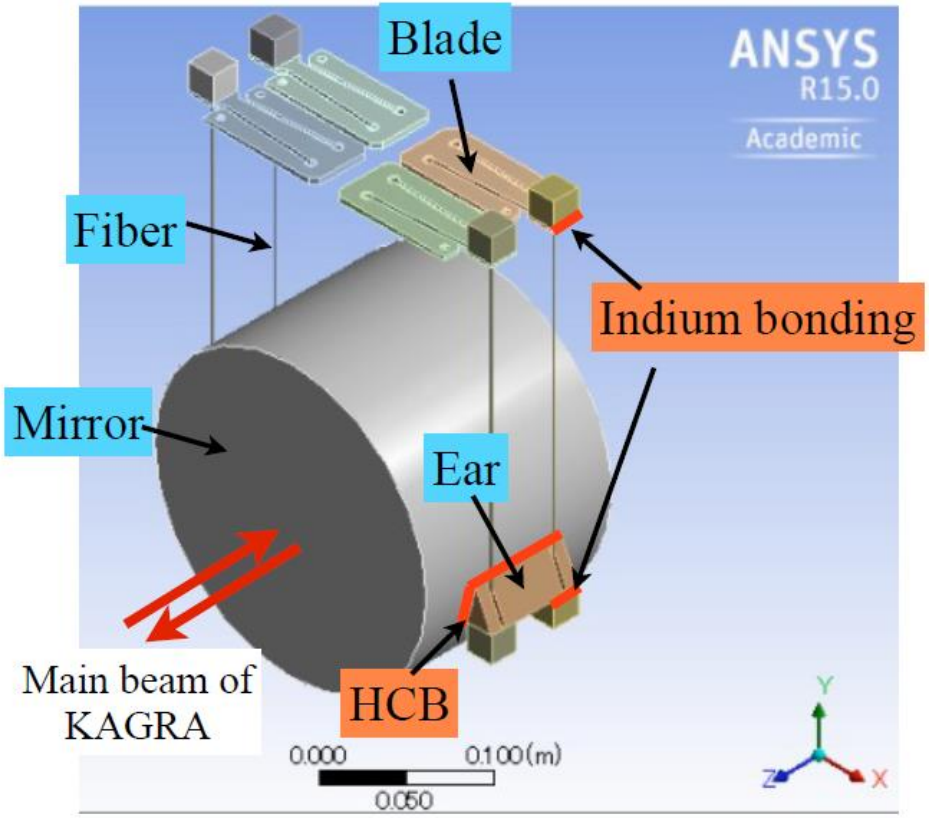
Update on Official Sensitivity

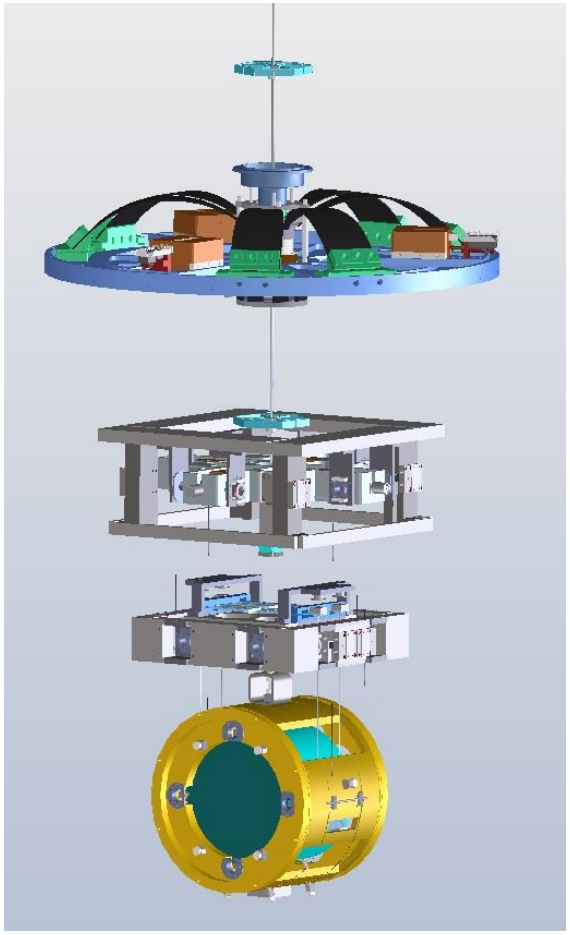
- 23 kg, 23 K, 550 W at BS → BNS 152 Mpc



Update details

- Update details (宗宮さんに聞く、オフィシャル感度更新は2009年以来？、2009年感度との比較にするか、麻生PRD2013との比較にするか)

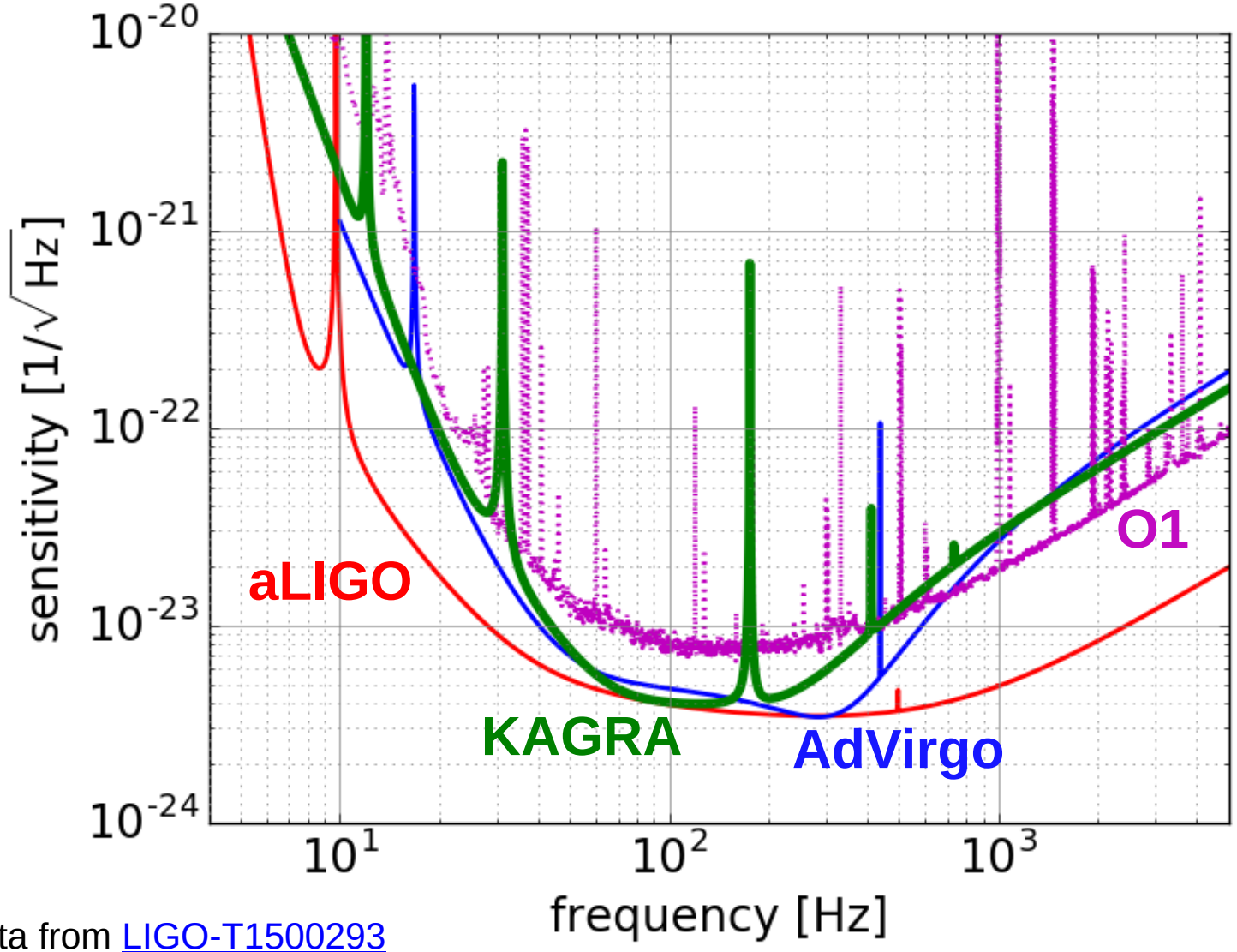




Figures from Kieran Craig

KAGRA vs Other 2G

- Not better even with cryogenic and underground



Spectra data from LIGO-T1500293

KAGRA vs Other 2G

- Lower power and lighter mass increase quantum noise
- Thick sapphire increase suspension thermal noise (low frequency sensitivity is not limited by underground seismic noise)
- 他に言うことは？

Ideas for Improving Sensitivity

- Increase the mass
  - composite mass
  - A-axis sapphire mass
  - non-cylindrical mass
  - go silicon (upto 200 kg, 45 cm dia.)

A-axisのサイズと重さ
かまぼこのサイズと重さ
サファイア結晶から鏡を
くり抜く図

- Focus on low frequency
  - low laser power, thin and long suspension
- Filter cavity
  - effectively increase mass and laser power
- ETM different from ITM, half-cryogenic, delay-line, folded arms, higher-order modes …… ???

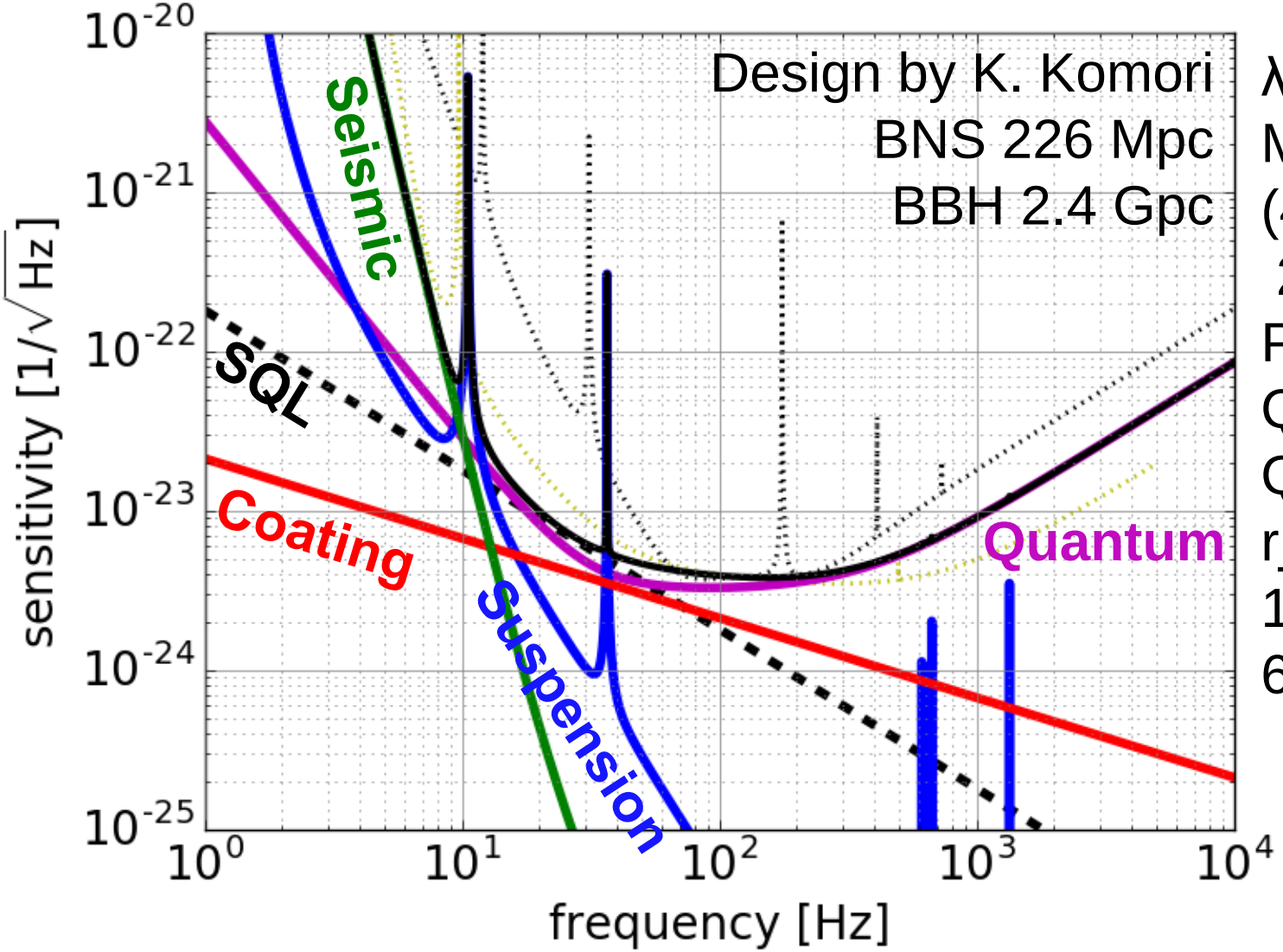
Example KAGRA+ Sensitivity 1

- Heavier mass (榎本くん？)

Example KAGRA+ Sensitivity 2

- Silicon 123 K, radiative cooling

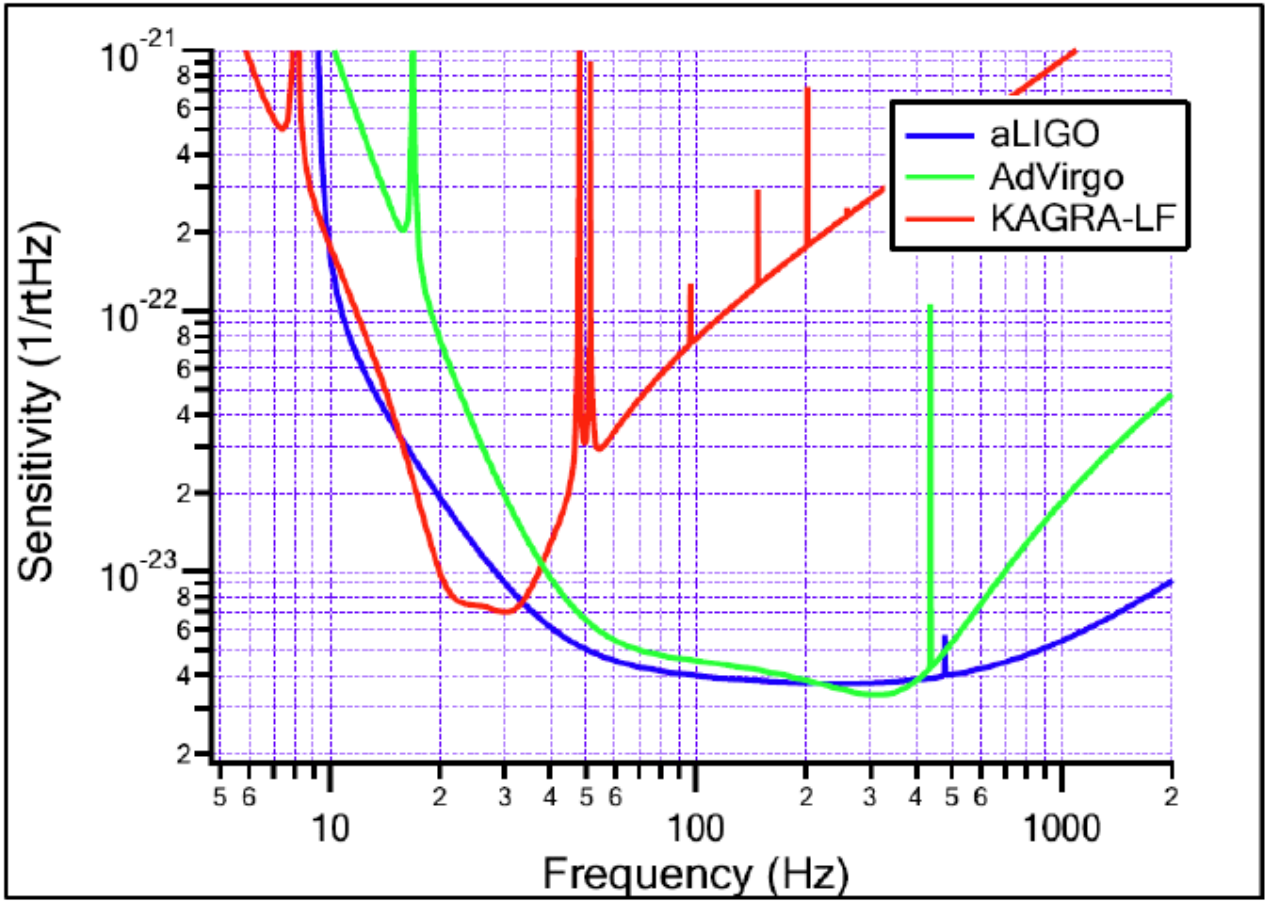
要相談



λ = 1550 nm
Mass: 73 kg
(40 cm dia.,
25 cm thick)
P_BS: 500 W
Q_susp: 1e8
Q_coat: 1e4
r_beam: 7 cm
100m F. C.
6 dB SQZ

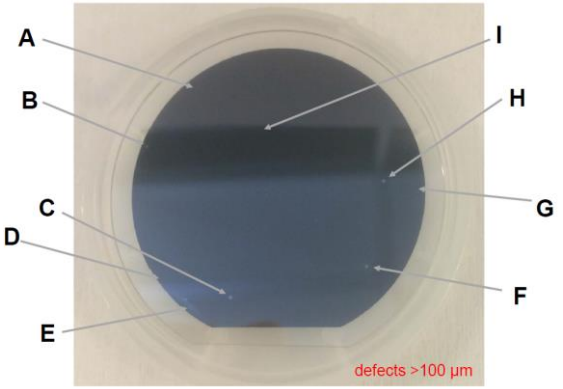
Example KAGRA+ Sensitivity 3

- Low frequency (宗宮さんにスペクトルをもらう)

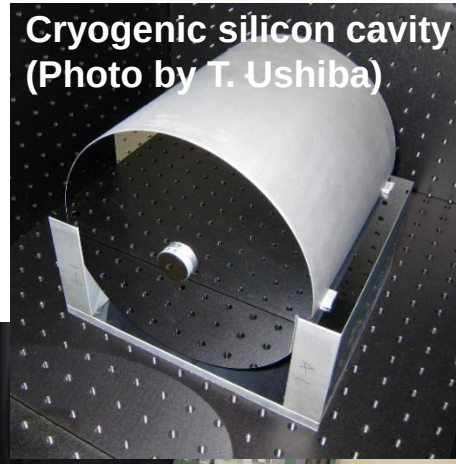


R&D Activities

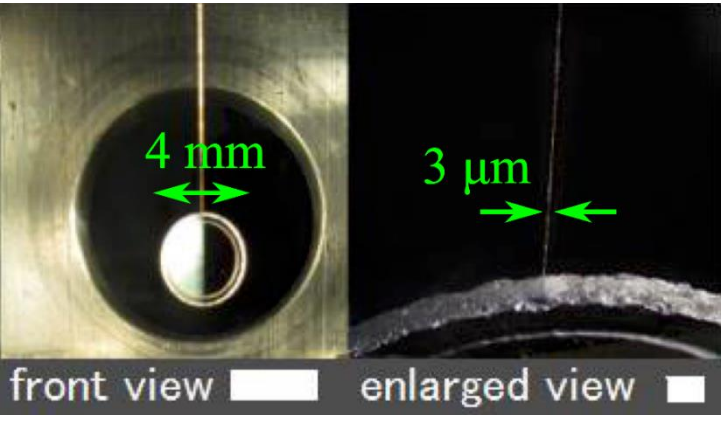
- Crystalline coating on sapphire
- Cryogenic silicon cavity for thermal noise measurements
- Mirror absorption characterization
- 300m filter cavity at TAMA300
- Quantum radiation pressure noise measurement with mg-scale mirror

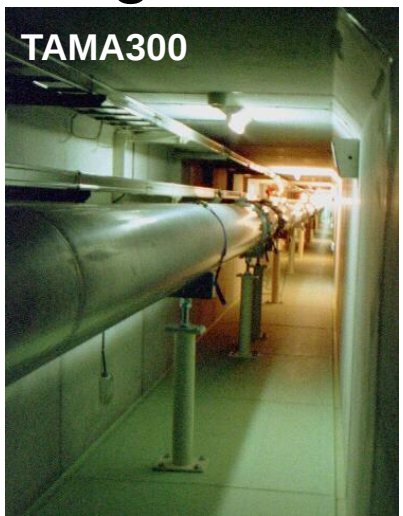


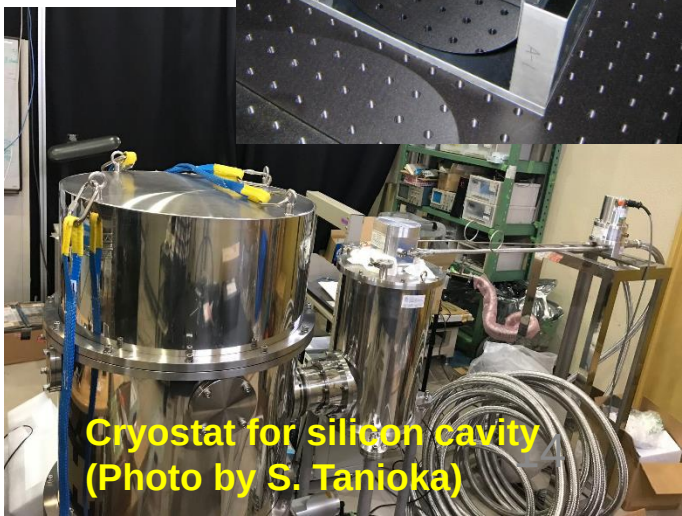
2-inch GaAs/AlGaAs on sapphire
6ppm scattering, 9 large defects
(M. Marchio, R. Flaminio;
Photo from Y. Aso JGW-G1605361)



N. Matsumoto, K. Komori *et al.*:
PRA 92, 033825 (2015)







KAGRA+ Planning Schedule

- February 2017:
  Informal brainstorming
- March 2017:
  Call for volunteers
- June 2017:
  Organize 2-3 teams
- August 2017:
  Report proposal from 2-3 teams
  → select one proposal

これでいい？
予算やどういう組織で
議論しているかの話は？

Summary

- R&D on-going for future KAGRA upgrade
- Integrated sensitivity design study on KAGRA+ initiated recently

Supplementary Slides

2G/2G+ Parameter Comparison

	KAGRA	AdVirgo	aLIGO	A+	Voyager
Arm length [km]	3	3	4	4	4
Mirror mass [kg]	23	42	40	80	200
Mirror material	Sapphire	Silica	Silica	Silica	Silicon
Mirror temp [K]	23	295	295	295	123
Sus fiber	35cm Sap.	70cm SiO_2	60cm SiO_2	60cm SiO_2	60cm Si
Fiber type	Fiber	Fiber	Fiber	Fiber	Ribbon
Input power [W]	55	125	125	125	140
Arm power [kW]	290	700	710	1150	3000
Wavelength [nm]	1064	1064	1064	1064	2000
Beam size [cm]	3.5 / 3.5	4.9 / 5.8	5.5 / 6.2	5.5 / 6.2	5.8 / 6.2
SQZ factor	0	0	0	6	8
F. C. length [m]	none	none	none	16	300

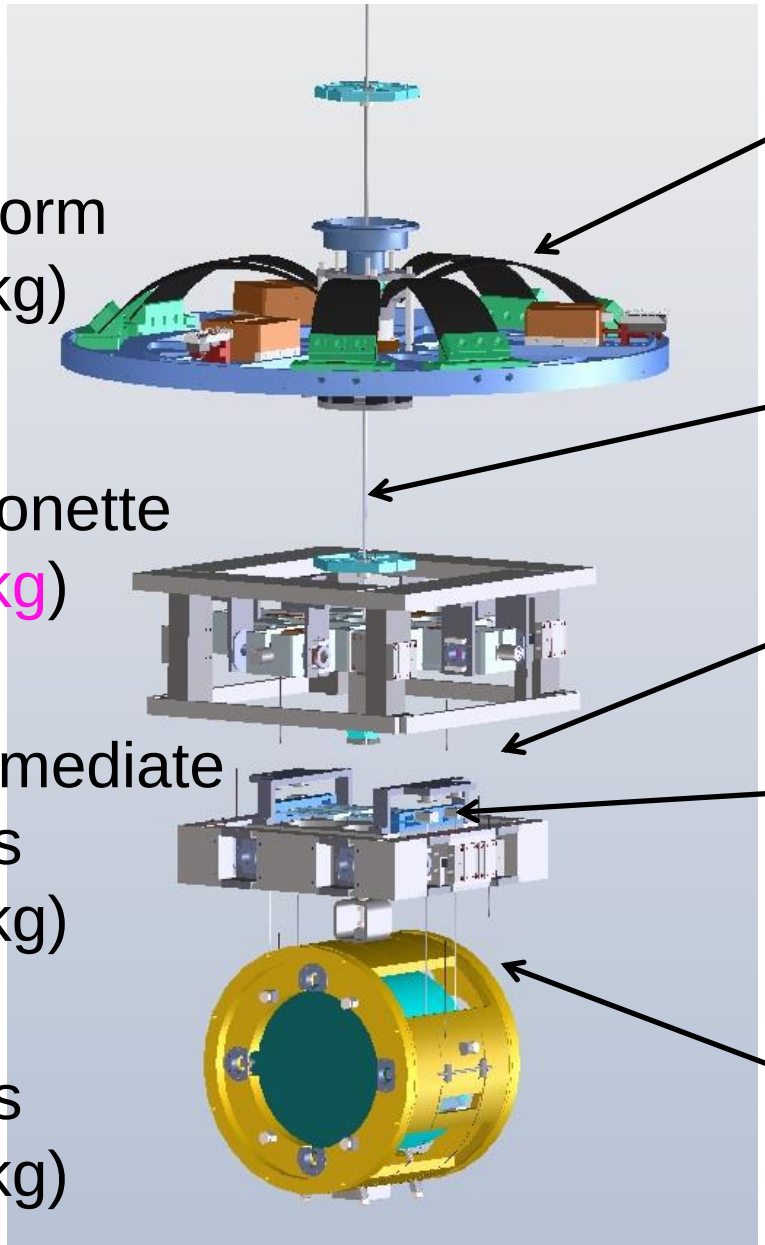
LIGO parameters from LIGO-T1600119, AdVirgo parameters from JPCS 610, 01201 (2015)

KAGRA Detailed Parameters

- **Optical parameters**
  - Mirror transmission: 0.4 % for ITM, 10 % for PRM, 15.36 % for SRM
  - Power at BS: 550 W
  - Detune phase: 3.5 deg (DRSE case)
  - Homodyne phase: 133 deg (DRSE case)
- **Sapphire mirror parameters**
  - TM size: 220 mm dia., 150 mm thick
  - TM mass: 22.8 kg
  - TM temperature: 23.1 K
  - Beam radius at ITM: 3.5 cm
  - Beam radius at ETM: 3.5 cm
  - Q of mirror substrate: 1e8
  - Coating: tantala/silica
  - Coating loss angle: 3e-4 for silica, 5e-4 for tantala
  - Number of layers: 9 for ITM, 18 for ETM
  - Coating absorption: 0.5 ppm
  - Substrate absorption: 80 ppm/cm
- **Suspension parameters**
  - TM-IM fiber: 35 cm long, 1.6 mm dia.
  - IM temperature: 16.3 K
  - Heat extraction: 6580 W/m/K
  - Loss angle: 5e-6/2e-7/7e-7 for CuBe fiber?/sapphire fiber/sapphire blade
- **Inspiral range calculation**
  - SNR=8, fmin=10 Hz, sky average constant 0.442478

パラメータが合っているか確認

KAGRA Cryopayload



Platform
(47 kg)

Marionette
(20 kg)

Intermediate
Mass
(23 kg)

Test
Mass
(23 kg)

CuBe blade springs

各部の温度とワイヤの長さは？

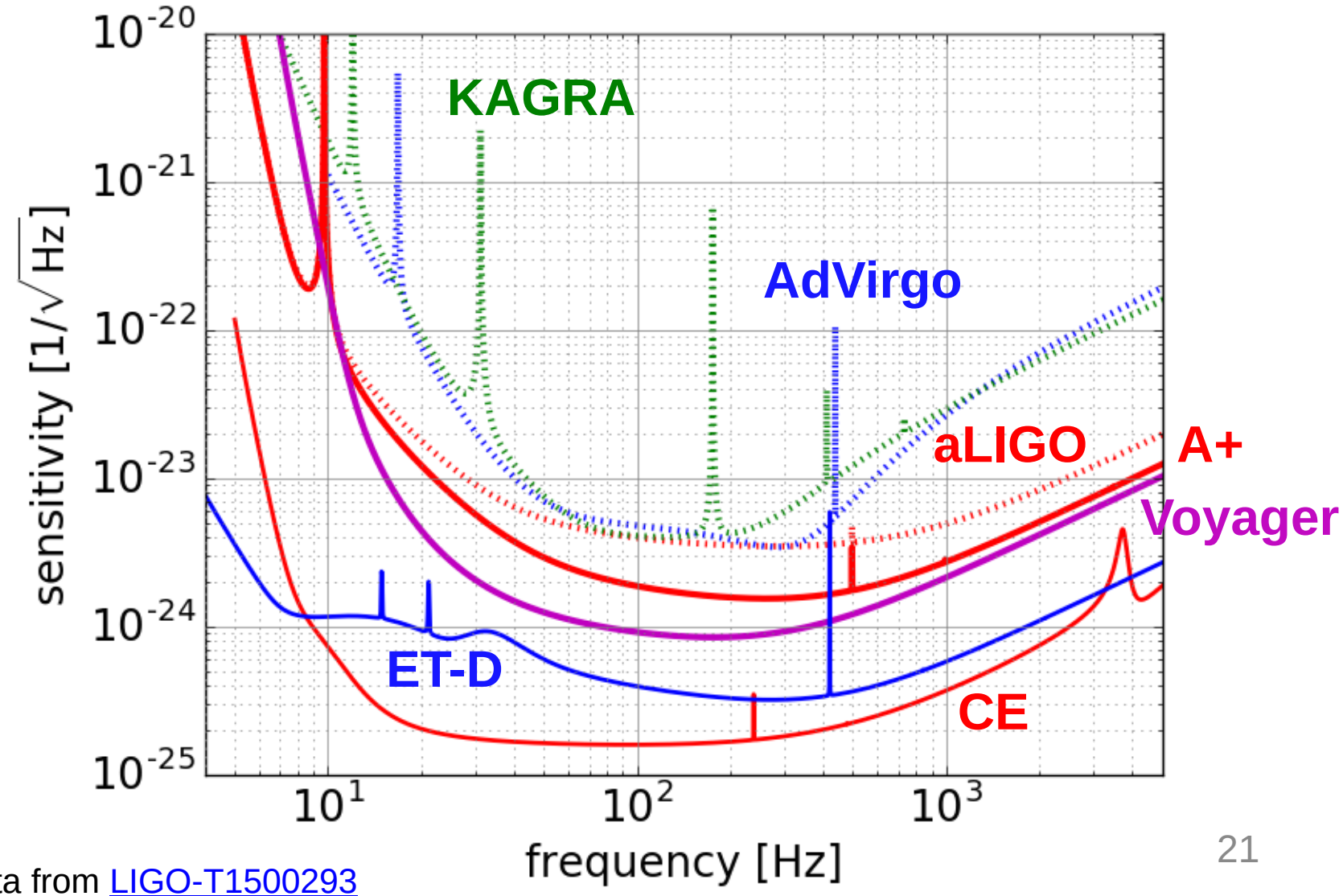
MN suspended by CuBe fibers

IM suspended by CuBe fibers
IRM suspended by CuBe fibers

Sapphire blades

TM suspended by sapphire fibers
RM suspended by CuBe fibers

2-3G Sensitivity Comparison



Spectra data from [LIGO-T1500293]

Other References

- K. Somiya, 感度について JGW-G1605698
  On recent official sensitivity update
- K. Somiya, KAGRA2020 JGW-G1503551
  Slides for GWADW2015 on KAGRA upgrade
- K. Somiya *et al.*: LCGT-LF report JGW-T1100446
  Study report on a reconsideration of the LCGT bandwidth for low-frequency measurements
- M. Ando *et al.*: Study report on LCGT interferometer observation band JGW-T1000065